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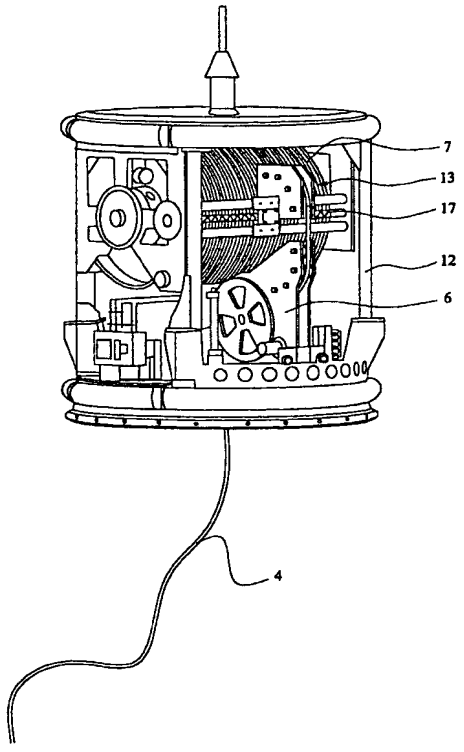
[Continued on next page]

(54) Title: SYSTEM FOR FEEDING LINE

(57) Abstract: A tether management system (1) including a drum (7) of tether (4) includes a pivoted fairlead (6) which pivots about a tether exit hole (8) arranged below the drum (7). The system guides tether (4) vertically into the exit hole (8).



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System for Feeding Line

The present invention is concerned with a system for feeding and/or guiding a flexible line or conduit and a fairlead for guiding a line from a supply of line to a line feed station. Embodiments of the present invention are particularly useful in connection with sub-sea tether management systems (TMS') for remotely operated vehicles (ROVs).

A fairlead may be defined as a block, ring or similar through or over which a line is rove or guided to, for example, keep it clear of obstructions, prevent chafing, or maintain it at an angle.

Remotely operated vehicles (ROVs) for sub-sea use in, for example, gas and oil field maintenance, may be deployed using a tether management system (TMS). In a TMS, an ROV is deployed inside or under a garage or frame which includes a store of tether or umbilical cord and means for feeding out and retracting the tether or umbilical cord. The garage or frame includes a drum of tether or umbilical cord for the ROV which is deployed from the TMS frame when this is lowered to the appropriate working depth.

The garage or frame is connected to a vessel from which it is deployed or lowered. Once the tether management system (TMS) is at the appropriate depth the ROV carries out its tasks by being deployed relative to the TMS frame to which it is connected by an umbilical cord or tether. The tether typically carries electrical conductors and communications conductors.

When spooling a tether (or tube, cable or wire) off or onto a winch drum, the tether or wire leads at an angle to the drum centreline. This angle known as "fleet angle" is dependent on the width of the drum, the position along the drum from which the tether is being spooled at a particular moment and the distance of the next pulley from the drum. If the distance from the drum to the next pulley is small and the width of the drum is high, the fleet angle is high and damage can occur to the spooling equipment and/or tether.

On a tether management system (TMS), one is typically using large amounts of tether (requiring a large drum) and trying to keep space (and overall size of the TMS and TMS frame) to a minimum (leading to a small distance from drums to next pulley). A TMS therefore typically has a high fleet angle. The tether typically exits the TMS through an exit hole in the bottom of the TMS which may house a latch onto which the ROV may be latched. If the fleet angle is high, the tether will rub on the edge of the hole. Tether or umbilical cords for remotely operated vehicles include power and communication cables. These are relatively fragile and rubbing of the cable may therefore damage the tether.

Prior art systems have sought to reduce the problem of tether rubbing against the edge of its exit hole by one of two methods. The tether can be routed through a bend restrictor (see figure 2), which can take the form of a large spring or flexible tube, or the tether can be routed over a series of

fixed position pulleys (see figure 3) to enable a straight approach to the exit hole to be made.

The present invention in a first aspect provides a system as defined in claim 1 to which reference should now be made.

The system of claim 1 helps to ensure that the tether drops vertically into the exit hole and thereby helps to reduce or eliminate rubbing of the tether against the edge of the exit hole.

The pivoting fairlead of claim 1 allows one to maintain a constant angle of approach of the line to a line feed station as line is spooled from different positions along a spool. The pivoting of the fairlead allows it to follow the position of the line as it leaves a supply of line.

Preferred features of the invention in its first aspect are set out in dependent claims 2 to 13 and 20 to which reference should now be made.

A tether management system typically includes an alignment surface against which the line is pressed and thereby aligned. It is known to provide pressure rollers above the alignment surface which press on the line to force it against the surface.

If only one pressure roller is used the potential for damaging relatively fragile lines such as tethers or umbilical cords for remotely operated vehicle is great as all the required pressure has to be exerted at one point. The more pressure rollers used, the less pressure exerted by each roller. The problem, however, with installing several rollers is the space required to do so.

The present invention in a second aspect provides a fairlead according to claim 14 to which reference should now be made. The line retaining means of the present invention means that the line is likely to be securely retained whilst being less likely than in some of the prior art systems to be damaged by excessive point pressure.

Preferred features of the invention in its second aspect are set out in dependent claims 15 to 19 to which reference should now be made.

By way of example, an embodiment of the present invention will now be described with reference to the accompanying figures in which:

Figure 1 is a schematic illustration of the deployment of a tether management system embodying the present invention;

Figure 2 illustrates a known fairlead or tether guiding system for use in a tether management system;

Figure 3 illustrates an alternative known fairlead or tether guiding construction for use in a tether management system;

Figure 4 illustrates a tether management system incorporating an embodiment of the present invention;

Figure 5 is a sectional view along section V-V of figure 4;

Figure 6 illustrates a detail of the tether management system of figures 4 and 5 not shown in these figures;

Figure 7 illustrates a fairlead construction embodying the present invention; and

Figure 8 illustrates the tether retaining arrangement used with the fairlead of figure 4.

A tether management system (TMS)1 (see figure 1) is deployed from and connected to a surface vessel 2. A remotely operated vehicle (ROV) 3 is coupled to the TMS 1 by a tether or umbilical cord 4. The tether typically includes electrical and communications connections which are fed back to the surface vessel via the strain member or cable 5 which suspends the TMS 1 from the surface vessel 2.

The tether management system is coupled to a control system on the vessel which typically includes a video or CCTV display connected to cameras on the ROV coupled to the TMS and includes controls for controlling the movement of the ROV 3 and depth of the TMS 1.

Tether management systems include a powered winch which feeds out or pulls in tether 4 as the ROV 3 is operated. The tether is guided by fairlead 6 from the drum 7 on which it is stored through a latch that docks (attaches) the ROV 3 to the TMS 1 when the ROV is not being deployed remote from the TMS.

As tether 4 is spooled in or out from the drum 7 to the dock/latch or a TMS tether exit hole 8, it approaches exit hole 8 or the dock/latch from different angles as the tether comes off at different points along the length of the drum 7. This variation in angle of approach of the tether 4 to the exit hole 8 can cause the tether to rub against the exit hole 8 or latch during spooling in and spooling out operations.

The frictional and bending movement forces generated in tether management system (TMS) systems by the rotation and rubbing of the tether 4 against

the exit hole 8 can cause damage to the protective cover of the tether 4 and the electrical and optical conductors within the tether. This damage can lead to the tether breaking, or the damaged tether failing and causing seizure of the Tether management system (TMS).

Breakage of the tether causes the ROV attached to the tether to be lost. Seizure of the TMS causes lengthy delay in recovery and repair of the TMS and ROV.

It is known to reduce the damage to the tether during spooling operations by routing the tether 4 through a bend restrictor 9 (see figure 2), which can take the form of a large spring or flexible tube. It is also known to route the tether 4 over a series of fixed position pulleys 10 (see figure 3) to enable a straight approach to the exit hole 8 to be made.

Figures 4 to 8 illustrate a swivelling fairlead arrangement for use in a tether management system (TMS) of the type shown in figure 1.

A swivelling or pivoting fairlead 6 is pivotably mounted on a bearing 11 situated on the TMS frame 12 directly above the ROV docking latch and tether exit hole 8. The bearing 11 is hollow and allows the fairlead 6 to pivot about a vertical axis passing through the tether exit hole 8.

The tether 4 approaches the swivelling fairlead 6 from a level wind mechanism 13 through which tether is spooled onto or off the drum 7.

The level wind mechanism 13 includes level wind rollers 15 held between plates 16. The plates 16 are coupled to a screw member 17 and are arranged to move

along the screw member 17 so as to remain opposite the point on the drum 7 from or onto which line is being spooled. The level wind mechanism 13 spools line or tether 4 onto and off the drum 7 in a direction substantially perpendicular to the longitudinal axis of the drum 7. The tether drops substantially vertically from the fairlead 6 into the exit hole 8.

Tether 4 passes between the level wind mechanism 13 and the fairlead 6. The tether 4 enters the swivelling fairlead 6 from the level wind mechanism 13 via a series of rollers 18. The tether then leaves the rollers 18 and passes over a sheave wheel 19 before dropping vertically into the exit hole 8.

The fairlead 6 and level wind mechanism 13 are coupled (see figure 6 - coupling not shown in figures 4 and 5) so that the fairlead 6 pivots as the level wind mechanism 13 moves parallel to the longitudinal axis of the drum 7. The fairlead pivots together with the level wind mechanism 13 to keep the bottom level wind roller 20 substantially vertically above the top fairlead roller 21 and thereby keep the tether substantially vertical as it passes between the level wind mechanism 13 and the fairlead 6.

The fairlead 6 and level wind mechanism 13 are coupled together by a pair of scissor-like couplings 22. The couplings 22 are arranged on plates 23 fixed to the fairlead 6 and level wind 13. The plates serve to anchor the couplings to the respective element and are located either side of the entry and out points of the tether 4 from the level wind 13 and fairlead 6.

As shown in figure 6, each coupling has two extension arms 24, 25. One extension arm 24 has an end fixed to the fairlead 6 via the respective plate 23 and the other end running in a slot 26 in the level wind plate 23 so that it can move freely in the vertical direction. The other extension arm 25 crosses over the first arm 24 and is coupled thereto by a pivot 28. The second extension arm 25 has one end fixed to the level wind 13 via the respective plate 23 and the other end running in a slot 27 in the fairlead plate 23 so that it can move freely in the vertical direction.

The couplings 22 provide a rigid connection between the fairlead and level wind 23 in transmission of movement of the level wind 13 transverse to the fairlead 6 (i.e. parallel to the drum longitudinal axis) while allowing movement of the fairlead 6 away from the level wind 13 perpendicular to the drum longitudinal axis and direction of movement of the level wind 13 as the fairlead describes an arc. The scissor movement of the extension arms 24, 25 allows the fairlead 6 to pivot with the longitudinal movement of the level wind 13 although the fairlead 6 moves along an arc and the level wind moves in a straight line.

The tether 4 is held in firm contact with the sheave wheel 19 by a roller chain 29. The roller chain 29 comprises a number of rollers 30. Each roller 30 is shaped to the same profile as the tether and is linked to its neighbour by a flat link 31.

The upper end of the roller claim assembly 29 is fixed to anchoring screws 32, and the lower end of

the chain 29 is fixed via screws 33 to a tension adjusting device 34. The tension adjusting device 34 may be a screw or hydraulic cylinder. The tension adjusting device 34 allows one to alter the retaining pressure exerted on tether 4 to suit the environmental situation or operational circumstances.

In operation the driven sheave wheel 19 is used to drive tether out by turning anti-clockwise when viewed as in figure 4. Tether is pulled in by turning the drum 7 anti-clockwise when viewed as in figure 4. The motors driving the sheave wheel 19 and the drum 7 are set such that the drum overrides the sheave when the drum motor is actuated to turn the drum. The drum 7 and the sheave wheel 19 are each connected to the level wind mechanism 13 by separate chain and sprocket arrangements (not shown in figures) such that rotation of either the sheave wheel 19 or the drum 7 causes the feedscrew or screw mechanism 17 to rotate and hence move the level wind mechanism 13 along the screw 17. The sheave wheel 19 and drum 7 have sprockets engaging a chain which also engages sprockets on the end of the screw member 17. The sprocket and chain mechanisms are set up to provide a gearing between the drum sheave wheel 19 and the level wind 13 and a gearing between the drum 7 and the level wind 13 such that the level wind remain aligned with the point on the drum 7 onto or from which line 4 is being spooled at any one time.

When line 4 is being spooled from the drum 7, the driven sheave wheel 19 pulls line. Simultaneously, the sheave wheel 19 drives the level wind 13 via the chain and sprocket mechanism

mechanically linking the sheave wheel 19 and level wind 13. The couplings 22 between the level wind 13 and the fairlead 6 then mean that the moving level wind 13 then pivots the fairlead 6 (including the sheave wheel 19) so as to keep line 4 dropping substantially vertically into the exit hole 8.

When line is being spooled onto the drum 7, the drum 7 pulls line 4. Simultaneously, the drum 7 drives the level wind 13 via the chain and sprocket mechanism linking the drum 7 and the level wind 13. The couplings 22 then ensure that the moving level wind 13 pivots the fairlead 6.

A number of changes may be made to the embodiment of the invention described above. These may include the following, or any combination of the following:

The roller chain 29 may be replaced by a plurality of spring loaded wheels, a flat belt, fixed plate or it may be disregarded. A combination of these items may be used to achieve the required pressure between the tether 4 and the driven sheave wheel 19.

The fairlead assembly central bearing 11 may be solid centred or hollow to allow the tether to pass through. Bearings may be installed at other positions in addition to the central bearing.

The passage through the bearing housing 11 for the line 4 may include a rubber split ring 35 arranged around the line. This ring would have a slightly smaller internal diameter than the outer diameter of the line 4 so as to rub against the line.

The ring's rubbing serves to wipe or clean the line as it passes through the bearing housing 11.

A guide tube, trough, bars or spring or any combination of these items, may replace the series of rollers 15, 18, 20, 21 or they may be disregarded.

The driven sheave wheel 19 may be constructed from one or more components.

Sensors may be included to indicate the turns of the driven sheave wheel 19, load on the tether 4 from the driven sheave wheel 19, load on the tether 4 by an external source and the radial position of the fairlead 6.

The screws 32 used to anchor the roller chain 29 may have springs incorporated.

Claims

1. A system for feeding a flexible line or conduit comprising a supply or store of line (7), a line feed station (8) and a fairlead (6) for guiding line into and/or through the line feed station (8), wherein the fairlead (6)is pivotable about a substantially vertical axis passing through the line feed station (8) and the fairlead (6) guides line substantially vertically into and/or through the line feed station (8).

2. A system according to claim 1 wherein the line feed station is a hole (8).

3. A system according to claim 1 or claim 2 including a spool or drum (7) for storing line.

4. A system according to claim 3 wherein the line feed station (8)is arranged substantially underneath the spool or drum (7).

5. A system according to claim 3 or claim 4 including a line guide (13) for guiding line off or onto the spool or drum (7) and into or out of the fairlead (6), the line guide (13) being moveable parallel to the drum or spool's longitudinal axis so as to be substantially opposite the point on the drum or spool from which line is being taken or onto which line is being wound.

6. A system according to any preceding claim wherein the fairlead (6) comprises a first line receiving portion (21) for receiving line from or feeding line to the supply or store of line (7), a second line receiving portion for receiving line from or feeding line into or through the line feed station and a line receiving channel running between the first and second line receiving portions, wherein the second line receiving portion is located substantially vertically above the line feed station (8) and the first line receiving portion (21) is displaced from and pivotable about an axis passing substantially vertically through the line feed station (8).

7. A system according to claims 5 and 6 wherein the line guide (13) includes a first line receiving portion for receiving line from or feeding line onto the spool or drum and a second line receiving portion (20) for receiving line from or feeding line onto the fairlead (6), wherein the line guide's second line receiving portion (20) is coupled to the fairlead's first line receiving portion (21) such that the fairlead (6) pivots about the substantially vertical axis passing through the line feed station (8) as the line guide (13) moves substantially parallel to the spool or drum's longitudinal axis.

8. A system according to claim 7 wherein the fairlead (6) is coupled to the line guide (13) by at least one coupling (22) which can extend in a

direction transverse to the direction of travel of the line guide (13).

9. A system according to claim 8 wherein the coupling (22) comprises two arms (24, 25), each extending between different points on the fairlead (6) and line guide (13) and crossing each other therebetween, a first end of the first arm (24) being fixed at a first position on the fairlead and the second end of said first arm being slidable in a slot (26) in the line guide, a first end of the second arm (25) being fixed at a first position on the line guide (13) and the second end of said second arm being slidable in a slot (27) into the fairlead.

10. A system according to any preceding claim wherein the fairlead (6) includes a sheaved wheel (19) for receiving and guiding line.

11. A system according to claim 10 including a fairlead motor for driving the sheaved wheel (19) to pull line (4) from the supply or store of line (7) and feed it into and through the line feed station (8).

12. A system according to claim 3 or any of claims 4 to 11 when dependent thereon, including a spool or drum motor for driving the spool or drum (7) to pull line (4) from the fairlead (6) and thereby from and/or through the line feed station (8).

13. A system according to claims 11 and 12 wherein

the driven drum overrides the fairlead sheave wheel (19).

14. A fairlead (6) for guiding a line between a supply or store of line and a line feed station, the fairlead including a guiding surface for receiving and guiding line and line retaining means (29) for retaining a line in position against said surface wherein the line retaining means comprises a substantially continuous element extending over a significant portion of said guiding surface for pressing line against the guiding surface.

15. A fairlead according to claim 14 wherein the guiding surface receives and guides line placed above it.

16. A fairlead according to claim 14 or claim 15 wherein the line retaining means is a chain (29).

17. A fairlead according to claim 16 wherein the chain is a roller chain (29) including a plurality of linked discrete rollers (30).

18. A fairlead according to any of claims 14 to 17 including tensioning means (34) for tensioning the line retaining element.

19. A fairlead according to claim 18 wherein one end of the line retaining means (29) is anchored to a fixed point on the fairlead housing and the other is fixed to tensioning means such as a hydraulic cylinder or spring.

20. A system according to any of claims 1 to 13 including a fairlead according to any of claims 14 to 19.

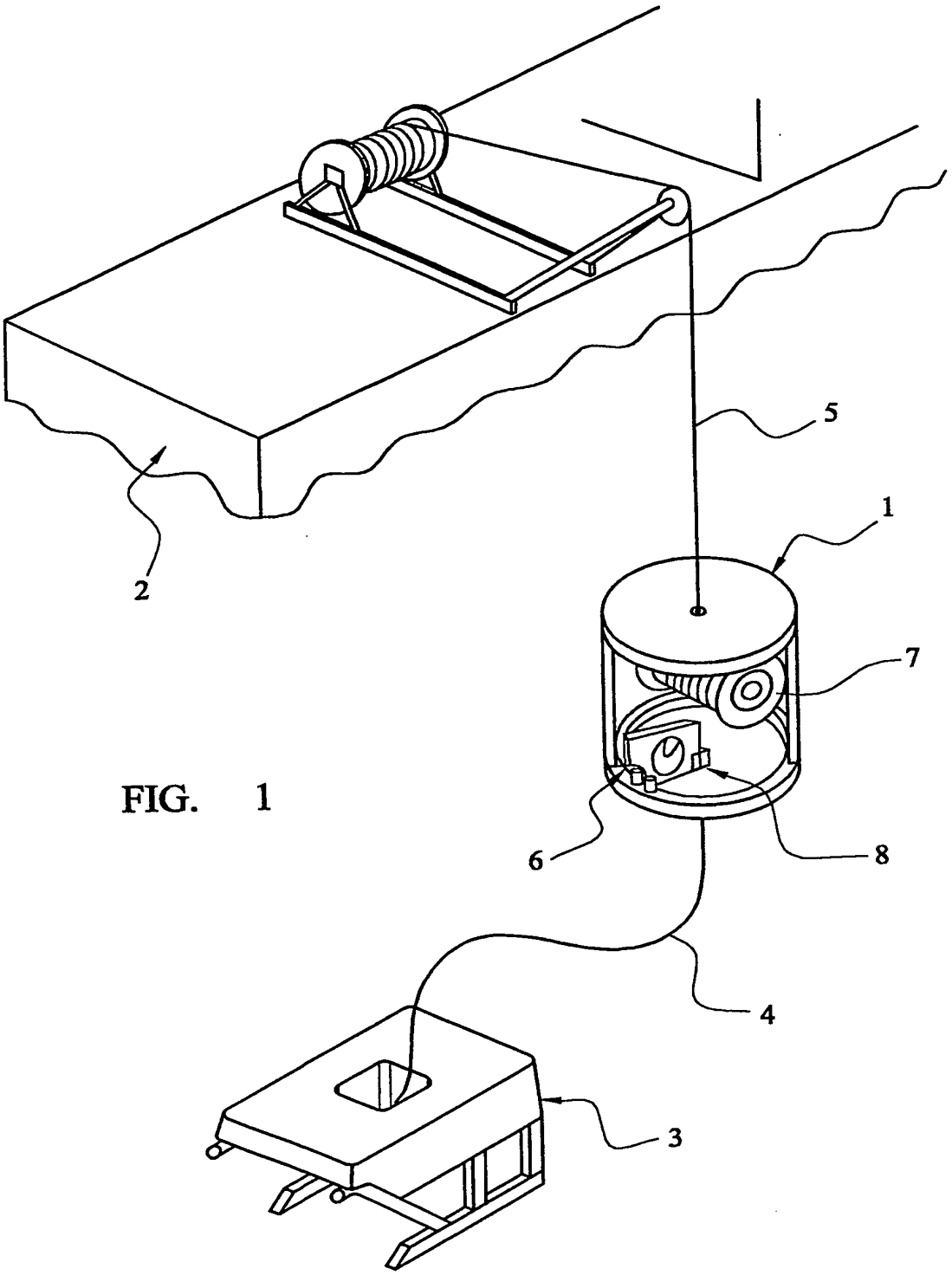

FIG. 1

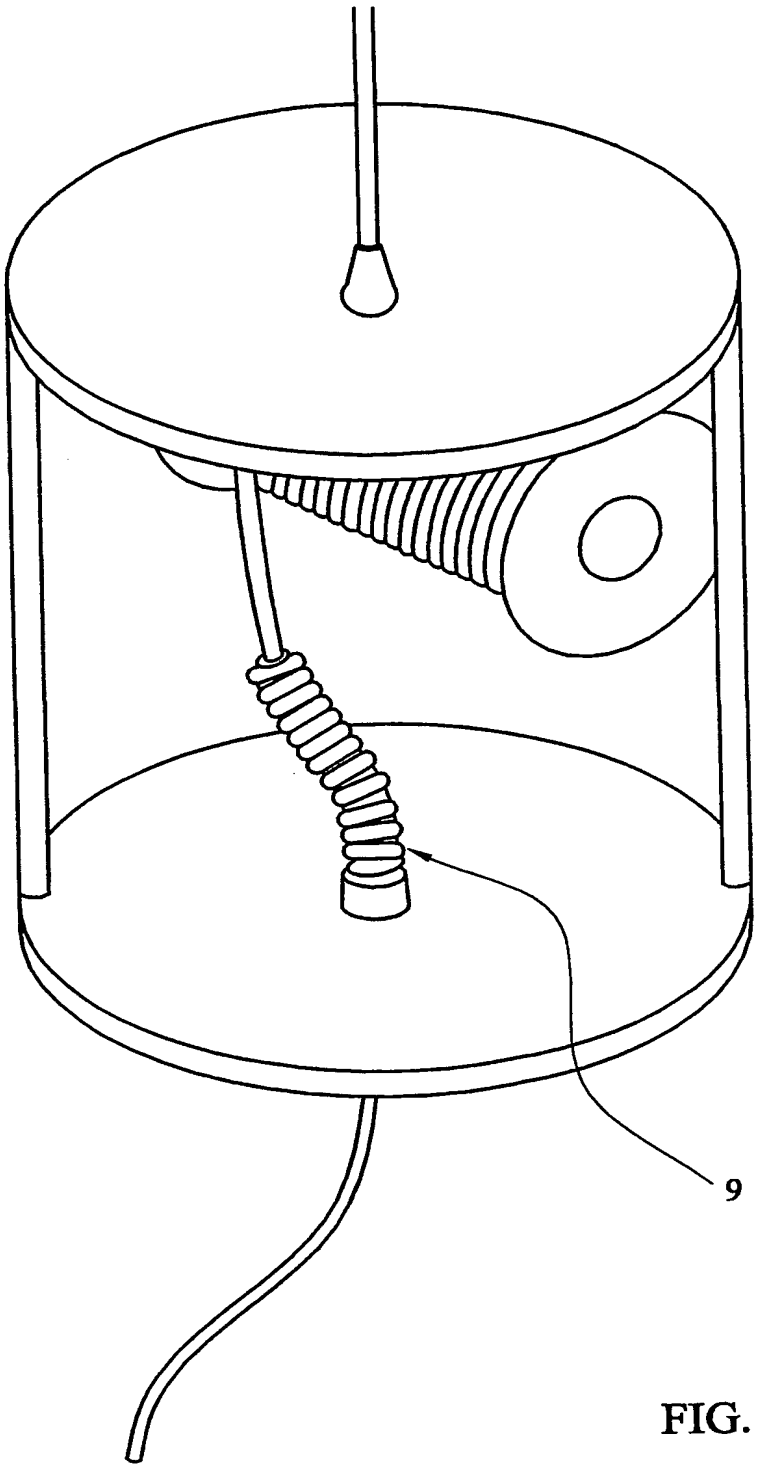

FIG. 2

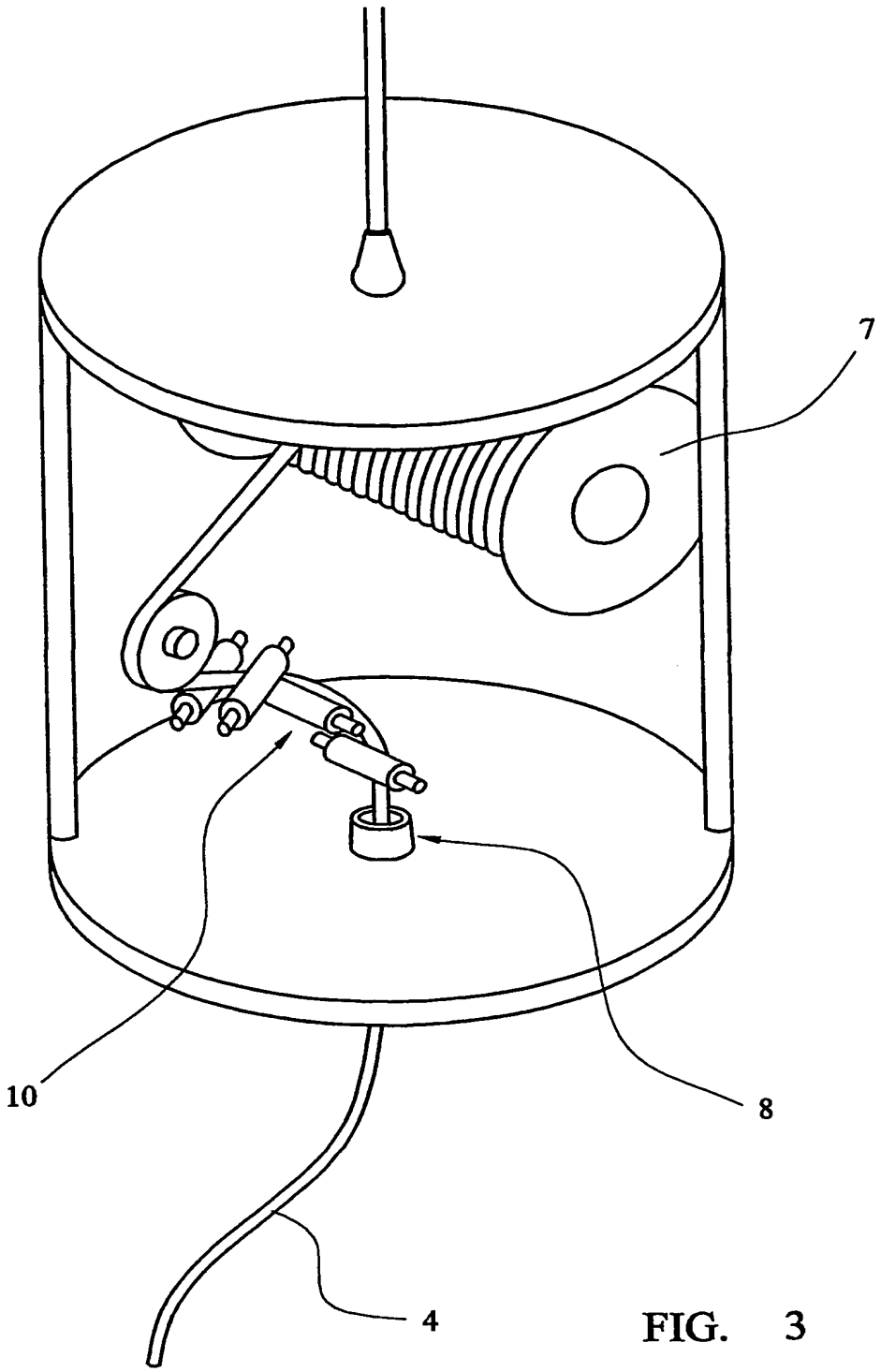

FIG. 3

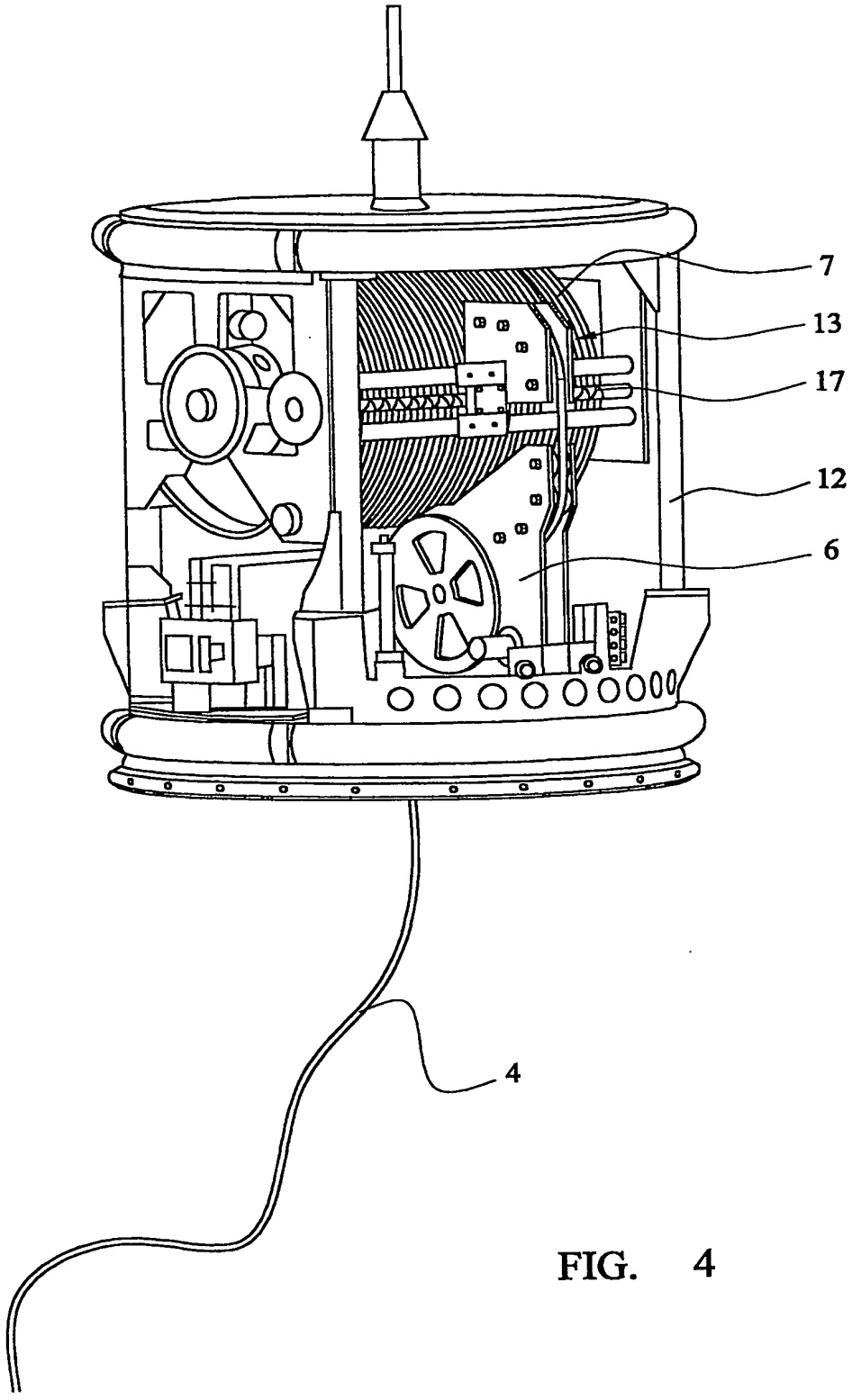

FIG. 4

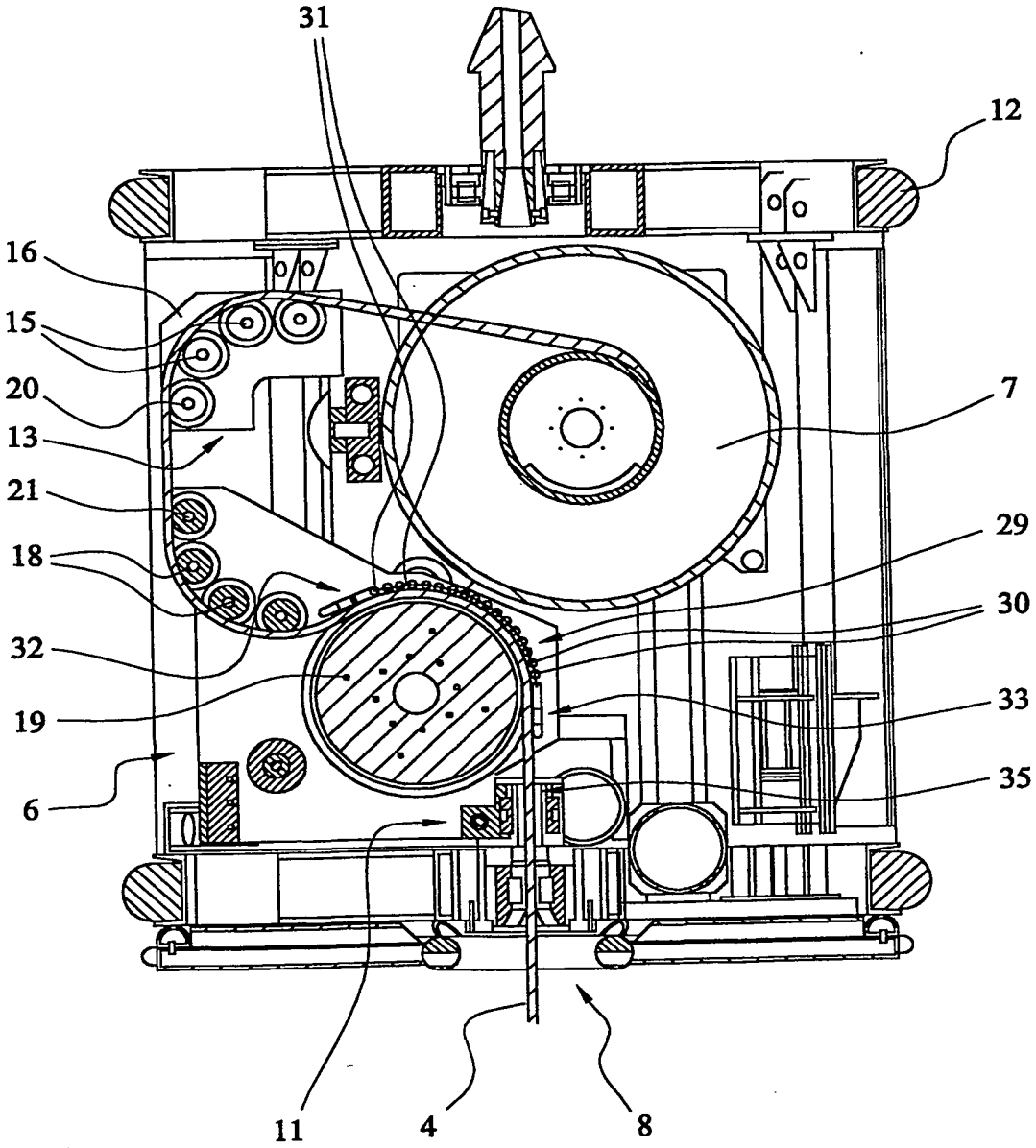

FIG. 5

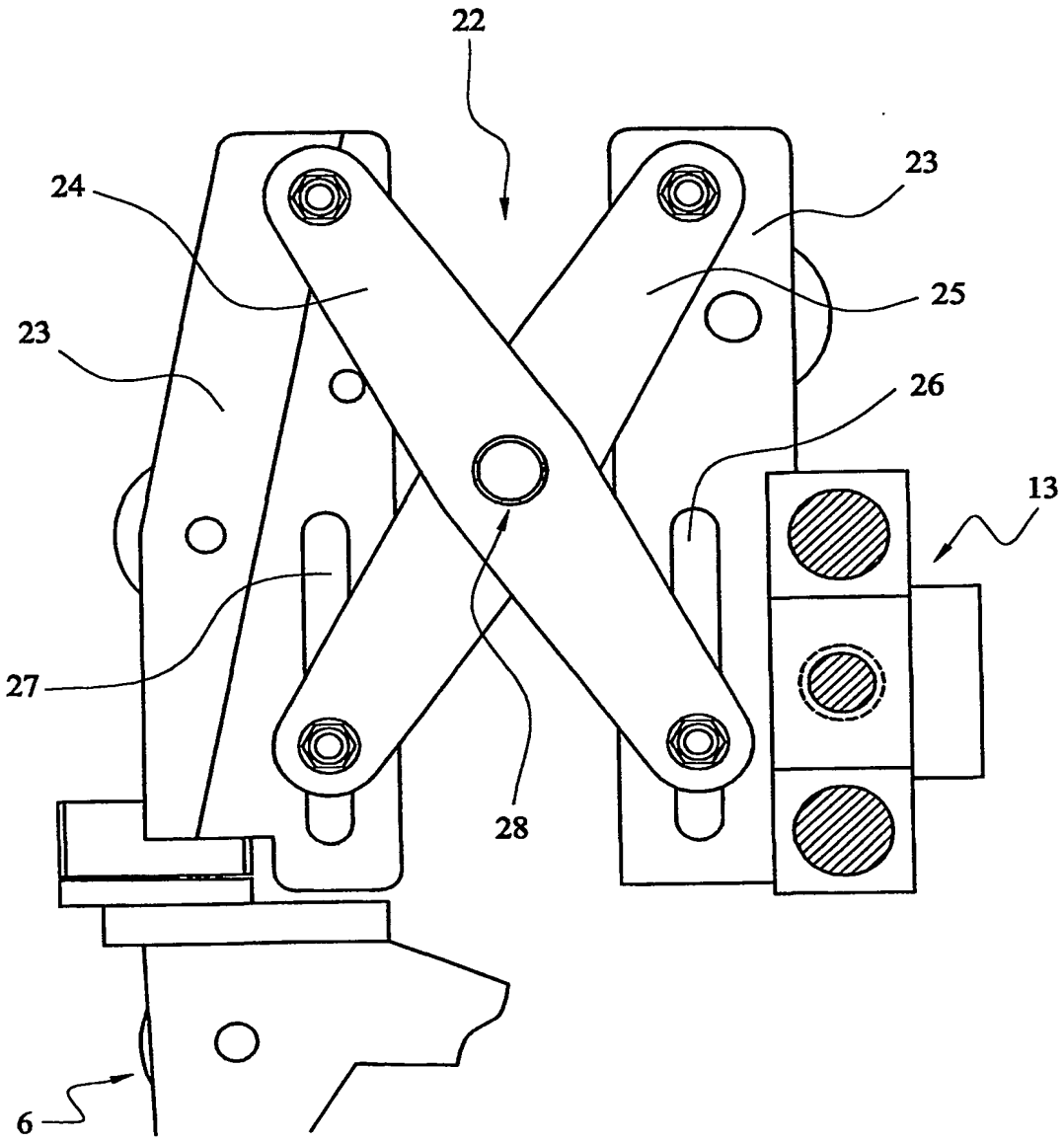

FIG. 6

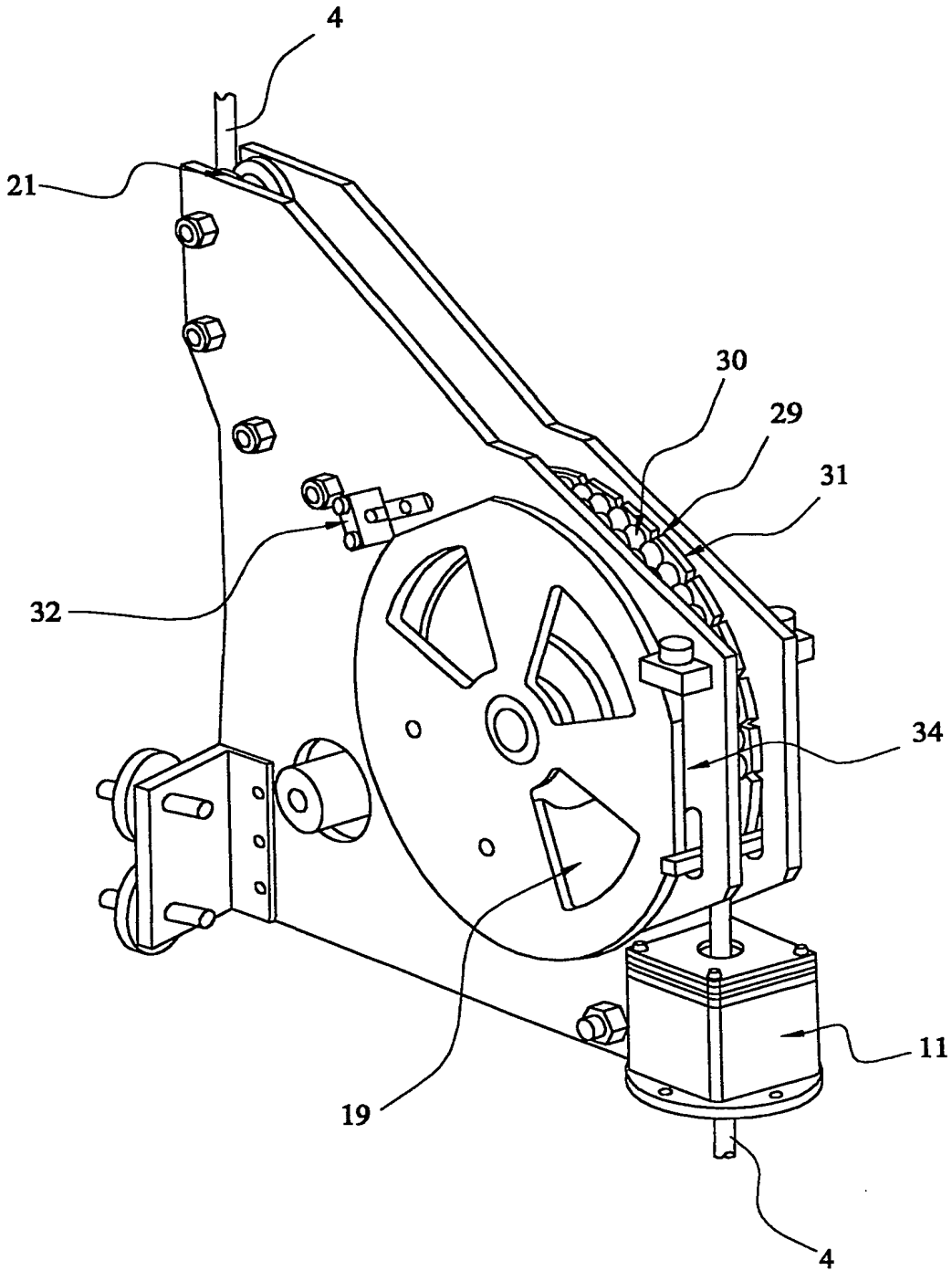

FIG. 7

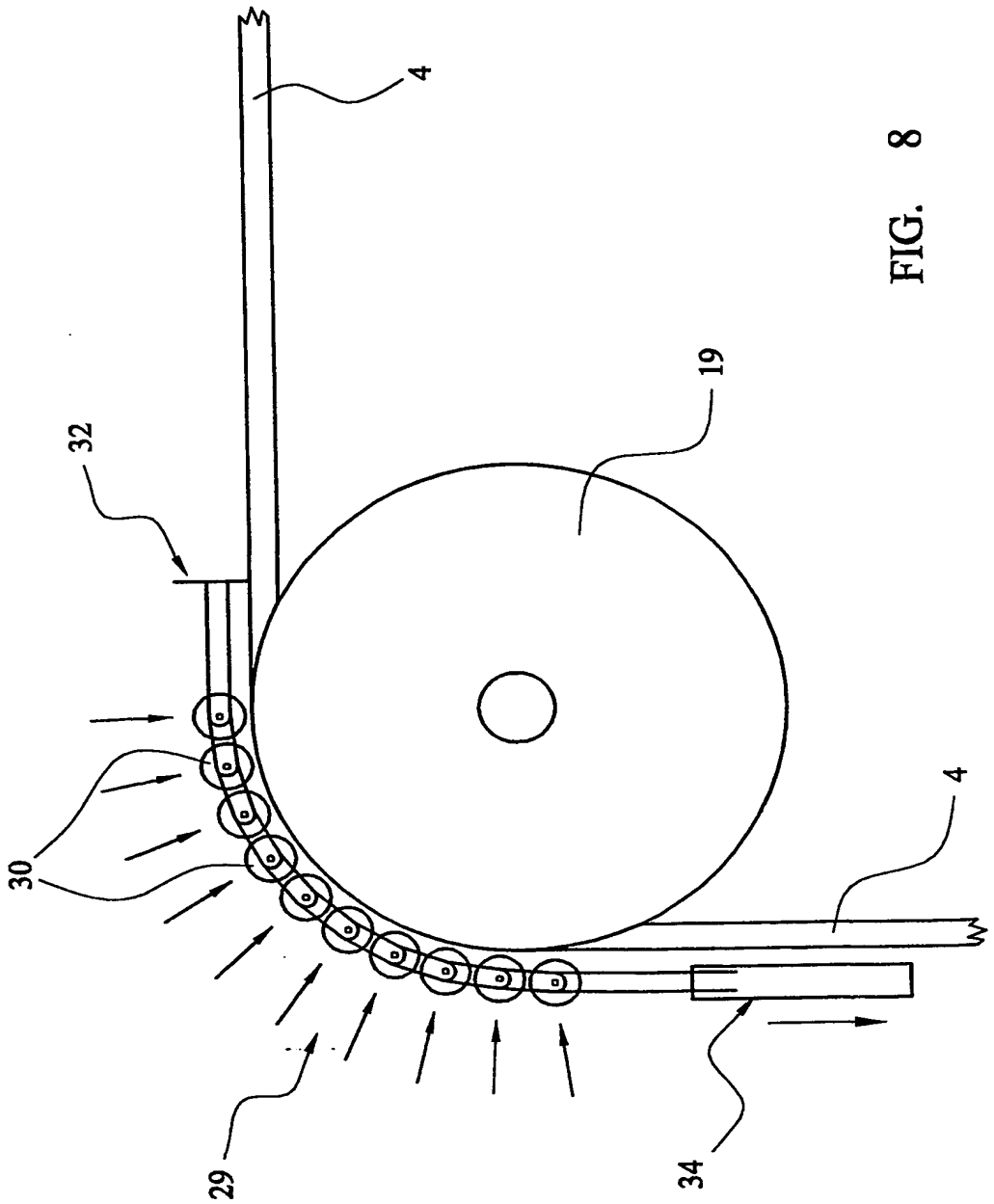

FIG. 8

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/GB 01/03204

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B65H75/34 B65H75/44 B65H57/28 B65H57/14 B63C11/00
B66D1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B65H B63C B63G F16L B66D H02G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 889 307 A (G.S. HOUOT) 17 June 1975 (1975-06-17) column 4, line 5 - line 15; figures	1-4,12
X	FR 2 743 359 A (NEREIDES) 11 July 1997 (1997-07-11) figures	1-3
X	US 3 020 567 A (R.B. COLT) 13 February 1962 (1962-02-13) figures	1-4
X	FR 993 133 A (J.E.R. GIRAUD) 8 November 1951 (1951-11-08) the whole document	1-3,5,12

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
23 October 2001	31/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	D'Hulster, E

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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X	CH 261 465 A (H. MARTIN) 15 May 1949 (1949-05-15) the whole document	1-3,5,12
X	PATENT ABSTRACTS OF JAPAN vol. 018, no. 016 (M-1540), 12 January 1994 (1994-01-12) & JP 05 254737 A (OHBAYASHI CORP;OTHERS: 02), 5 October 1993 (1993-10-05) abstract	1-3,5,12
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